Sensitivity and Linearity Test Weight Sensor Based on Polymer Optical Fiber with Circular Form and TiO_2 Nanoparticles as a Coating on Cladding

Yohana Putri Safitri[a)] and Heru Kuswanto[b)]

Physics Education Department, Faculty of Mathematics and Natural Science, Universitas Negeri Yogyakarta
Karangmalang Complex, Yogyakarta 55281, Indonesia

a)Corresponding author: yohana.putri@student.uny.ac.id
b)herukus61@uny.ac.id

Abstract. This research aims to know the sensitivity and linearity test weight sensor based on polymer optical fiber with circular form and TiO2 nanoparticles as a coating on cladding. Researchers also determined the concentration of the nanoparticle TiO2 liquid and the variation in diameter which give the greatest intensity change as well as the sensitivity and linearity best on the sensor. Fiber optic used are polymer optical fiber (POF) type SH-4001-1.3 with the refractive index 1.49 of the core and cladding refractive index 1.41. Nanoparticle TiO2 coating 5 mM as coating, the coating method using cladding on the peel along 150 cm. Diameter path POF in the form of a circle variation 4 cm, 5 cm and 6 cm by administering the treatment changes the mass of weight up to 1000 grams. The source of light used in this research is a Helium-Neon laser with a maximum power of 5 mW and wavelength of 632.8 nm. Helium-Neon lasers emit light through POF which is then received by the Optical Power Meter (OPM). The measured intensity of each laser signal attenuation caused by variations in mass changes, then in the normalization and linear plot with Ms. Excel to know the sensitivity and linearity. The best sensitivity is present on the sensor weight POF are coated TiO2 lap 6 cm in diameter with a gradient (2.33681 ± 0.13949) x 10-4 a.u/grams, where as the best linearity present on weight sensor POF pure path diameter 4 cm of 0.98674.

Keywords: Polymer Optical Fiber sensors, cladding, TiO2 nanoparticles.

INTRODUCTION

Fiber optic sensor is a type of optical sensor using polymer optical fiber (POF) in the sensing mechanism or detection, either as a component of the active sensor or just as a wave guide (optical). POF sensor working principles on measurements of power loss is going to the jacket with cladding. On the part of certain length POF, cladding there is a power loss so opened leaked. The fiber part opened serves as the sensor head. With the loss to leak then there is a difference between the input light power on one end of the fiber with external light power measured at the other end.[5] Along with its development, sensor technology POF has become a major part of the technology associated with the communications industry and optoelectronics of POF. There are several techniques to measure weight current i.e. piezoelectric, capacitive, hydraulic plate and plate weight is skewed, but that method has some drawbacks, namely corrosion, easy reach of small, speed prone to electromagnetic interference, low accuracy, manufacture, and installation of a hard, large size and high price.

POF sensor technology development which has the advantage of including high sensitivity, are resistant to electromagnetic interference, high temperature and corrosion compared to previous censorship can be an alternative for measuring weight. POF sensor based on the principle of loss of intensity of light caused by the bending of micro (micro bending) also has a good solid, simple structure, low cost and others. Thus the study of POF sensor with macro bending is very important.[3] In addition, research shows that the value of loss-power loss macro bending affected by the wave length, diameter of macro bending, and number of macro bending arranged in the shape of a coil that is used.[2] The last few years a lot of research test sensitivity and linearity on POF sensor with the technique of stripping buffer to obtain a more sensitive sensor, however this technique also has not shown significant results. With regard to these other techniques needs to be done to obtain a better POF sensor. One of these nanoparticles with application of titanium dioxide (TiO2) and methods of coating layer on POF cladding can be used to obtain the weight sensor with better sensitivity.

METHOD OF RESEARCH

Losses macro bending occurs when rays or light through an optical fiber that is bent with a radius greater than the diameter of the core optical fibers causing the losses as seen in Figure 1.[1]

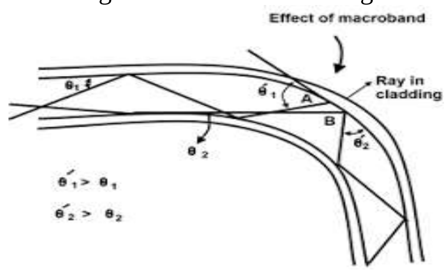
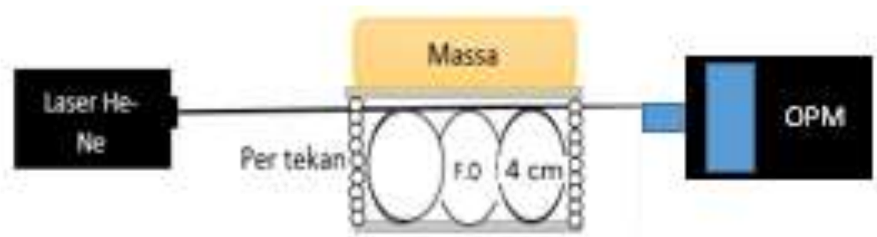


Figure 1. Events of losses due to macro bending.[4]

This research uses the source of Helium-Neon laser with a maximum power of 5 mW and wavelength of 632.8 nm, POF type SH-4001-1501.3 by refractive index 1.49 of core and cladding refractive index 1.41 of aqueous liquid of TiO_2 nanoparticles 5 mM, and Optical Power Meter (OPM) as a major component. Methods used namely coating to coat the cladding with TiO_2 nanoparticles. As for the method of coating that is warming up on the POF in soak in a solution of TiO_2 as much as 5 mM 100 mL for ± 1.5 hours until the cladding as overall and dried using the oven temperature remains 150º C, variations of path diameter circle (4 cm, 5 cm and 6 cm) as well as provide a weight to POF then measured intensity of the laser light through it any added burden then made the charts with application Origin 6.1. The scheme of the sensors and TiO_2 solution shown in Figure 2.

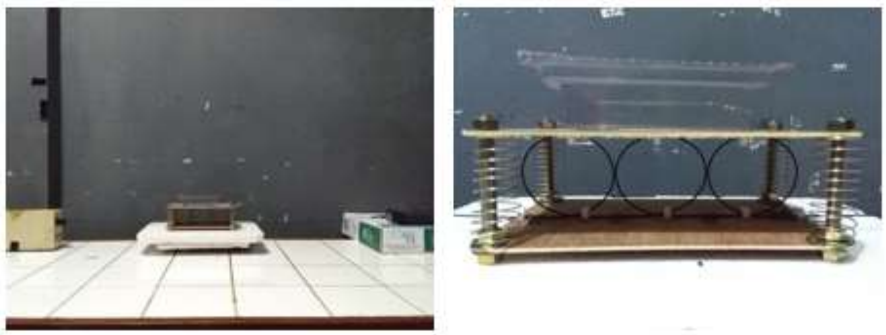


(a)

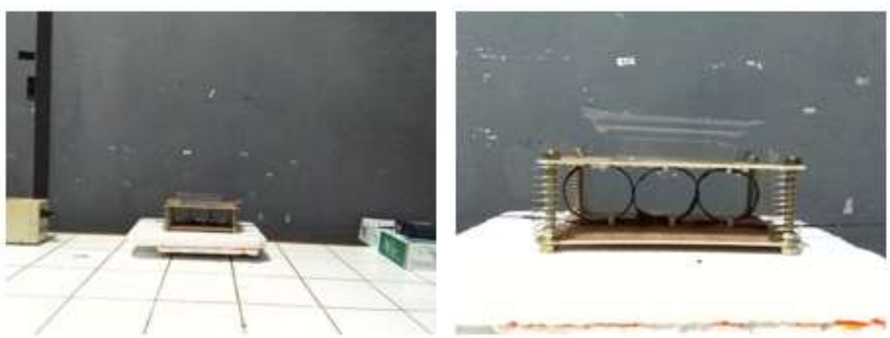
(b)

Figure 2. (a) The weight sensor-based trial scheme POF and (b) liquid of TiO_2

Subsequent research by looking at the relationship between pure POF and POF are coated with TiO_2 nanoparticles as a coating on cladding as a wide diameter of the circle with the intensity of the light output. This led to the diameter variation macro bending on POF. In the research tools organized in the scheme's early trajectory with a diameter of 4 cm which is then given a weight of between 200 – 1000 grams with added 50 grams for each data retrieval. Further data obtained created graphs with application Origin 6.1 and repeat the same steps for the variation of diameter of 5 cm and POF lap 6 cm on pure POF or POF with a layer of TiO_2 nanoparticles as a coating on cladding. The aim of this treatment is to compare the performance of sensors for each variation of pure POF or POF with a layer of TiO_2 nanoparticles as a coating on cladding diameter and its trajectory. Photo sensor experiment shown in Figure 3.



(a)



(b)

Figure 3. POF based weight sensor experiment (a) Pure POF (b) POF with TiO_2 nanoparticles as a coating on the cladding.

The stability of laser is a very important factor. The stability of laser greatly affects the value of the output intensity of the laser light is measured. The laser source is unstable causing a level of validity and reliability value of output light intensity decreases. Work done is set the other end of the stick on POF laser in steady state i.e. with how to insert the Cork which are then glued together.

RESULTS AND DISCUSSION

The experiment begins by measuring optical power on POF purely with three variations of the diameter of the trajectory. The results of the measurement of the normalized power output that has shown the graph in Figure 4. These results indicate that the greater the weight given then normalized power output will be getting smaller. Analysis of this data shows that linearity all the graphics are quite good on weight range 200 – 1000 grams. This means that the sensor has the potential of good accuracy for measuring the weight of the weight in the range. Data obtained from the graph parameters, where the value of the sensitivity is obtained from figures on the B parameter, while the linearity value is retrieved from the numbers on the parameters of comparison Results R. all data of the graph of weight sensor POF with variations 3 diameter (4 cm, 5 cm and 6 cm) obtained the value of the best sensitivity on POF pure with a diameter of 4 cm path $(1.95171 \pm 0.11099) \times 10^{-4}$ a.u/grams. While the best linearity on POF pure with the trajectory of diameter 4 cm of 0.98674.

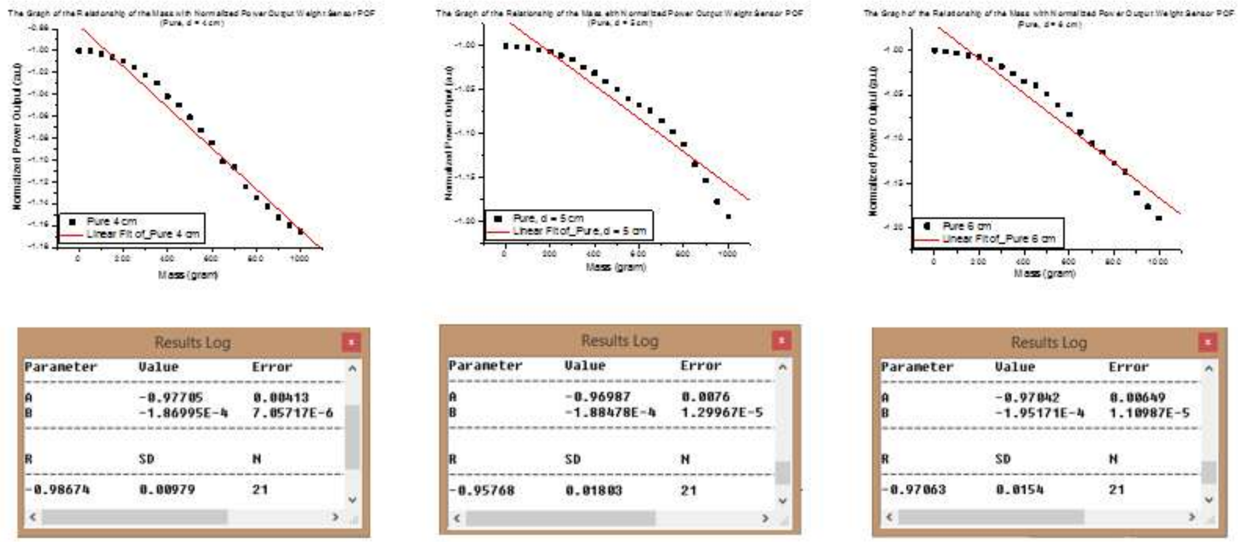
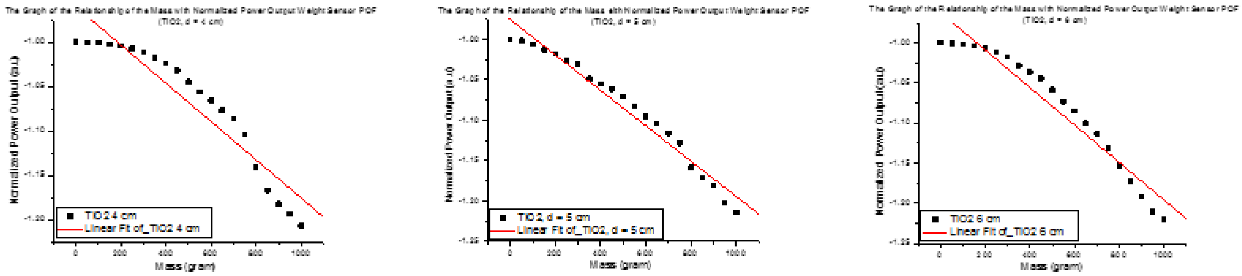


Figure 4. The graph of the relationship between normalized power output with mass of weight sensor on pure POF with diameter: (a) 4 cm, (b) 5 cm, and (c) 6 cm.

The second experiment is like the first trial but POF is given preferential treatment with peeling buffer for coating with TiO_2 nanoparticles 5 mM solution of using the oven temperature constant 150° C for 90 minutes. After the process of coating a POF has as TiO_2 wrapped with black tape TiO_2 layers to keep and reduce the risk of discharge light on POF. The results of this experiment measurement chart shown in Figure 5. These results indicate that the greater the burden of a given normalized power output then will be getting smaller. Analysis of this data shows that linearity all the graphics are quite good on weight range 200 – 1000 grams. This means that the sensor has the potential of good accuracy for measuring the weight of the weight in the range. Data obtained from the graph parameters, where the value of the sensitivity is obtained from figures on the B parameter, while the linearity value is retrieved from the numbers on the parameter R. data from the entire comparison Results graphic POF with TiO_2 nanoparticles as overlay cladding with variations 3 diameter (4 cm, 5 cm, and 6 cm) obtained the value of the best sensitivity on POF with TiO_2 nanoparticles as a cladding coating with the circular-shaped with a diameter of 6 cm $(2.33681 \pm 0.13949) \times 10^{-4}$ a.u/grams. While the best linearity POF with TiO_2 nanoparticles as a cladding coating with the circular-shaped with a diameter of 5 cm of 0.98293.



Results Log

Parameter	Value	Error
A	-0.96002	0.01007
B	-2.15255E-4	1.72256E-5
R	SD	N
-0.94421	0.0239	21

Results Log

Parameter	Value	Error
A	-0.97567	0.00548
B	-2.18569E-4	9.38222E-6
R	SD	N
-0.98294	0.01302	21

Results Log

Parameter	Value	Error
A	-0.96221	0.00815
B	-2.33681E-4	1.39488E-5
R	SD	N
-0.96778	0.01935	21

Figure 5. The graph of the relationship between the normalized power output with mass of weight sensor POF with TiO_2 layer as cladding coating on the trajectory with diameter: (a) 4 cm, (b) 5 cm, and (c) 6 cm

Of the whole experiment has been done can be obtained the best sensitivities on the whole data POF with TiO_2 nanoparticles as upholstery cladding for every variation of the diameter of the circle and the best result on POF with TiO_2 nanoparticles as upholstery cladding with a diameter of 6 cm of trajectory (2.33681 ± 0.13949) x 10^{-4} a.u/grams. As for the best linearity POF purely with the trajectory of diameter 4 cm of 0.98674.

I. CONCLUSION

Researchers examine the principle macro bending on POF for weight sensor-based functions as POF. The experiment results show that macro bending led to a weakening of the optical signal and power losses. The presence of a layer of TiO_2 nanoparticles are able to create sensor-based weight POF from pure more sensitive, especially on lap diameter 6 cm. But a layer of TiO_2 nanoparticles have yet to affect the results of linearity. Future application of TiO_2 nanoparticles as a layer of cladding coatings can be applied on other sensor based POF.

ACKNOWLEDGMENTS

This authors would like to thank the Faculty of Mathematics and Natural Science, State University of Yogyakarta for supporting this research especially The Spectroscopy Laboratory and The Colloid Laboratory..

REFERENCES

1. Andre, A.,2006, *Fibers for Strengthening of Timber Structures*, pp. 41-66. Technical report. Lulea University of Technology, Swedia
2. Barani, Imee R.R. (2014). *Pengaruh Rugi-rugi Macrobending Terhadap Kinerja Plastic Optical Fiber Jenis Step Index Multimode*. Jurnal Teknik Elektro. pp. 1-6
3. Bin Ma and Xinguo Zou. *Study of Vehicle Weight-In-Motion System Based on Fiber-optic Microbend Sensor.*2010. InternationalConference on Intelligent Computation Technology and Automation
4. Gerd Keiser. 2000. *Optical Fiber Communication 3rd edition, Mc Graw-Hill.* United States of America
5. Khambali, Imam dan Endarko. (2014). *Rancang Bangun Sensor Polimer Serat Optik untuk Pendeteksi Konsentrasi Ion Ca+ dalam Air*. Jurnal Materi dan Pembelajaran Fisika. Volume 4 Nomor 2, pp. 32-37